

(19) World Intellectual Property Organization  
International Bureau



(43) International Publication Date  
27 September 2001 (27.09.2001)

PCT

(10) International Publication Number  
**WO 01/71647 A1**

(51) International Patent Classification<sup>7</sup>: **G06K 9/00**

(21) International Application Number: **PCT/US01/08979**

(22) International Filing Date: **20 March 2001 (20.03.2001)**

(25) Filing Language: **English**

(26) Publication Language: **English**

(30) Priority Data:  
60/191,171 22 March 2000 (22.03.2000) US  
09/812,228 19 March 2001 (19.03.2001) US

(71) Applicant: **LASER TECHNOLOGY, INC.** [US/US];  
7070 South Tucson Way, Englewood, CO 80112 (US).

(72) Inventors: **POLAND, Richard, J.**; 10135 E. Peakview  
Avenue, Englewood, CO 80111 (US). **MILLER, Eric,**  
A.; 4540 S. Jason Street, Englewood, CO 80120 (US).  
**DUNNE, Jeremy, G.**; 2686 East Otero Place, #11,  
Littleton, CO 80122 (US). **WILLIAMS, David, W.**;  
1501 W. Dry Creek Road, Littleton, CO 80120 (US).

**FRISCHMAN, Mark**; 5155 Spectra Way, Unit 1, Missis-  
saugua, Ontario (CA). **CLIFFORD, Bruce**; 5155 Spectra  
Way, Unit 1, Mississauga, Ontario (CA).

(74) Agents: **BURTON, Carol, W.** et al.; Hogan & Hartson  
LLP, Suite 1500, 1200 17th Street, Denver, CO 80202-5840  
(US).

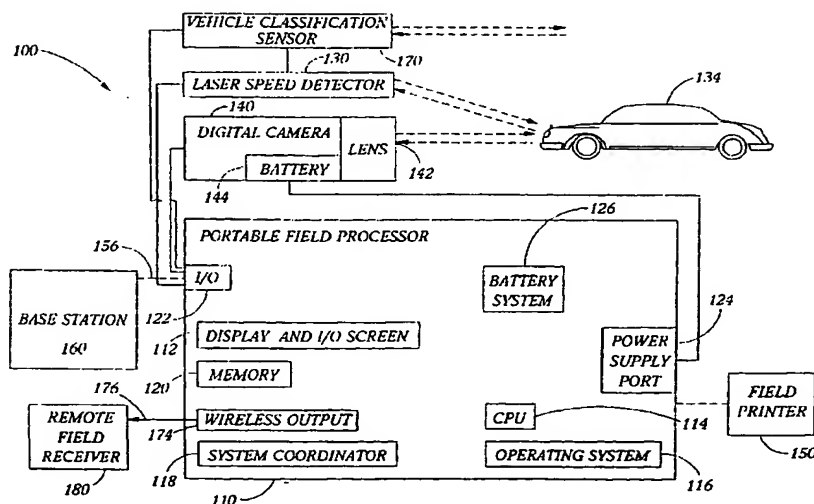
(81) Designated States (*national*): AE, AG, AL, AM, AT, AU,  
AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU,  
CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM,  
HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK,  
LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX,  
MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL,  
TJ, TM, TR, TT, TZ, UA, UG, UZ, VN, YU, ZA, ZW.

(84) Designated States (*regional*): ARIPO patent (GH, GM,  
KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian  
patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European  
patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE,  
IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF,  
CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published:  
— with international search report

[Continued on next page]

(54) Title: **COMPACT SPEED MEASUREMENT SYSTEM WITH ONSITE DIGITAL IMAGE CAPTURE, PROCESSING, AND PORTABLE DISPLAY**



(57) Abstract: A compact speed measurement system for field or onsite use in measuring speeds of vehicle and capturing images of select vehicles. The system includes a laser speed detector for determining a speed of a vehicle in a specific target area. When a speed is determined, the detector generates a speed signal. The system includes a camera (140) generally aligned with the speed detector (130) operable to capture and store digital still images of vehicles (134) in memory. The camera is programmed to respond to an image capture signal to generate and transmit a digital image file including a still image of the vehicle targeted by the detector. A portable field processor (110) is communicatively linked to the speed detector and the camera to first receive the speed signal, to process the speed signal and to transmit an image capture signal to the camera, and to receive the digital image file from the camera.

BEST AVAILABLE COPY

WO 01/71647 A1

**WO 01/71647 A1**

---



*For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.*

## COMPACT SPEED MEASUREMENT SYSTEM WITH ONSITE DIGITAL IMAGE CAPTURE, PROCESSING, AND PORTABLE DISPLAY

### BACKGROUND OF THE INVENTION

#### Field of the Invention

5           The present invention relates, in general, to speed detection of moving vehicles, and more particularly to compact, mobile speed detection systems that provide for accurate speed detection with accompanying image capture, processing, and production at the location of the field portion of the system, such as the present location of the law enforcement vehicle.

#### 10       Relevant Background

          Law enforcement agencies and personnel presently use a variety of speed measurement devices to monitor traffic and, more particularly, to identify vehicles that are going faster than posted speed limits. In addition to identifying a speeding vehicle, it has become increasingly common to attempt  
15       to capture images of such speeding vehicles and then to use the images to better enforce the speed limits (i.e., use the image as part of a ticketing program). While satisfying some of the needs of the law enforcement agencies, the existing speed measurement and image capture devices have not proven suitable or reliable for many law enforcement agency applications and have  
20       created operational problems that hinder the field use of such devices.

          Various methods are used to detect the speed of moving vehicles, such as well-known radar systems. More recently, speed detection systems have incorporated lasers to accurately detect the speed of a moving vehicle and also the distance or range of the vehicle from the laser device. In  
25       general, laser speed detectors measure the time delay between the transmission of a series of pulses and a reflection of those pulses. The design and operation of laser speed detection and range finder systems may be found in U.S. Pat. No. 5,359,404 entitled "Laser-Based Speed Measuring Device, U.S. Pat. No. 5,652,651 entitled "Laser Range Finder Having

Selectable Target Acquisition Characteristics and Range Measuring Precision", and U.S. Pat. No. 6,057,910 entitled "Self-Calibrating Precision Timing Circuit and Method for Laser Range Finder", which are each incorporated herein by reference. Typically, these laser speed detection  
5 systems provide accurate measures of a vehicle's speed and are useful for providing onsite speed measurements, e.g., at the location of a law enforcement vehicle, that could then be entered on a ticket by law enforcement personnel.

Improvements have been made to increase the accuracy and  
10 usefulness of these laser-based speed detection systems. For example, U.S. Pat. No. 5,938,717 entitled "Speed Detection and Image Capture System for Moving Vehicles", which is incorporated herein by reference, discloses a system for accurately aligning a laser speed detector and for capturing an image of a speeding vehicle with a video camera. The system also provides  
15 the advantage of automating the capture of images of speeding vehicles at a predetermined distance from the system and of capturing a set of useful information (e.g., date, time, location, speed limit, detected speed, and the like). A computer system is included in the disclosed system to run a frame grabber program to capture a frame of the video image. The computer  
20 system includes a removable data storage device for storing the captured image frames and the associated set of information.

Generally, the system is taught to be operated by placing the system in a selected location to monitor vehicle speeds, such as along a road with the bulky computer system position in the back of a van or other vehicle. The  
25 system is initially set up by an operator and then allowed to operate automatically without or with minimal operator control for a certain period of time. An operator then removes the data storage device from the system and takes the data storage device back to a separate office or facility for processing of the captured images (i.e., grabbing a still image from the video)  
30 and data with a computer system at the office. In this manner, tickets can be produced by combining the video image with the collected data and then

mailing the ticket to owners of vehicles that violated a speed limit by a selected amount (such as 5 miles per hour in a school zone and 10 miles per hour for a highway). A hardcopy of the image may be included with the ticket with the data being overlaid by the office computer system. In some applications, the field computer system, such as a personal computer, includes a monitor to allow an operator to view the collected image and to facilitate entering of field parameters. Additionally, the field computer system may perform some of the processing features (such as overlaying of the set of information on a grabbed frame of the video) and may include a thermal printer to produce copies of the image with the overlaid information at the field unit.

While addressing some of the needs of law enforcement agencies, the video-based laser speed detection systems have not addressed all of the operating problems facing field operators and are not particularly useful in some field applications. For example, the use of frame grabbing with a video camera for image capturing is most effective with a relatively high capacity and higher speed data processing system and large data storage capacity. Typically, the computer requirements are met with a personal computer with central processing unit with a frame grabber PC card installed and associated monitor and keyboard. The combined use of a video camera with a personal computer results in a bulky package that is often costly and is usually physically large, which limits its usefulness in the field. It is not convenient or even practical for a single operator, i.e., law enforcement officer, to quickly deploy the system and then periodically move the entire system or portions of the system without moving the whole vehicle in which the system is positioned. The portability of these video-based systems is further limited by the need for a large number of communication cables and power cords (e.g., generally AC and DC power provided to each component) between the various components.

One of the most significant advantages of a laser-based speed measurement instrument is its ability to narrowly target a single car within a group of cars. However, there is still a need for proof that the detected speed

is matched with the correct car. This proof can be provided with the overlaid information if it is accurately synchronized with the proper, grabbed video frame. Of course, this synchronization and combining of information requires additional processing capacity that increases the cost and sometimes the size  
5 of the system. Also, the time required to process the information and to print out a hard copy of the produced image limits its desirability as evidence or proof of speeding in the field as enforcement officers demand relatively quick to support the issuance of a speeding ticket.

Hence, there remains a need for a device or system for detecting a  
10 speed of a moving vehicle and for capturing an image of the vehicle that provides an accurate determination of the vehicle's speed along with readily accessible proof that the speed has been correctly matched to the proper vehicle. Preferably, such a speed measurement device would be designed for field use (such as inside or outside an operator's vehicle) providing prompt  
15 and useful evidence of a vehicle's speed while also being compact, lightweight, and easy to operate. The device would also preferably be useful in various weather conditions, provide protection of collected images and data, and be relatively inexpensive to purchase and operate.

#### SUMMARY OF THE INVENTION

20 The present invention addresses the above discussed and additional problems by providing a compact and portable speed measurement and image capture system that combines an accurate laser speed detector with a programmable digital camera and a portable field processor. The portable field processor is configured to allow an operator to enter capture session and  
25 system parameters, such as a posted speed limit and a capture speed level, and to receive vehicle speed signals from the speed detector. The portable field processor operates to selectively transmit image capture signals to the digital camera in response to these speed signals (e.g., generates image capture signals when the capture speed level is exceeded). The digital  
30 camera is programmed to retrieve a still image of the vehicle from its buffers or memory and create and transmit a digital image file (such as a file

compressed per JPEG standards). The portable field processor then writes the speed signal data into the digital image file and displays the combined file on a display screen. The portable field processor can then be detached from the system by a field operator to show the displayed image to a vehicle  
5 operator. In one embodiment, a classification sensor is provided to detect whether the vehicle is a commercial vehicle, such as by height measurements, axle counting, weight measurements, and the like, and two distinct capture speed levels are used to effectively capture images of private and commercial speeding vehicles that may different speed limits.

10 According to one aspect of the invention, a compact speed measurement system is provided for field or onsite use in measuring speeds of vehicles and capturing images of select vehicles. The system includes a laser-based speed detector for determining a speed of a vehicle in a specific target area. When a speed is determined, the detector generates a speed  
15 signal. The system also includes a camera generally aligned with the speed detector operable to capture and store digital-format still images of vehicles in memory. Specifically, the camera is programmed to respond to an image capture signal to generate and transmit a digital image file including a still image of the vehicle targeted by the detector. A portable field processor is  
20 communicatively linked to the speed detector and the camera to first receive the speed signal, to process the speed signal and in response transmit an image capture signal to the camera, and to receive the digital image file from the camera.

In a preferred embodiment, the portable field processor includes  
25 software to create a combined speed and image data file by modifying the digital image file to include speed data from the speed signal. For example, the digital image file may be a JPEG-format file and the modifying may involve writing the speed data to the header of the JPEG file. The portable field processor includes a display screen and is configured to display the  
30 modified digital image file on the display screen. An operator can then operate the field processor to enlarge and/or enhance selected portions of the

displayed image (such as to enlarge the license plate portion of the image). The field processor can be readily detached from the system and hand carried to a stopped vehicle to show the vehicle operator the displayed image as proof of their speed. To control the risk of data loss, the system is

5 configured such that the digital camera acts as a charging power source for the field processor, i.e., the camera will stop operating before the field processor loses power thus assuring storage of all captured images.

According to another aspect of the invention, a method is provided for measuring a speed of a moving vehicle and capturing a digital image of the

10 same moving vehicle. The method involves initially positioning and setting up a speed detector and a camera at a location selected by an operator for targeting vehicles moving through a target area. The camera is operated on an ongoing basis to capture or temporarily store a still image of each vehicle passing through the target area. The speed detector operates on an ongoing

15 basis to determine the speed of a specific vehicle in the target area. The speed data including the determined speed is transmitted to a portable field processor. The speed data is processed by the field processor, which responds by transmitting a trigger signal to the camera. The camera receives the trigger signal, responds by retrieving a still image corresponding to the

20 targeted vehicle, and then transmits the still image in a digital image file to the portable field processor.

In one embodiment of the method, several of the functions are synchronized to insure that the captured image is an image of the same moving vehicle that was targeted by the speed detector. This is achieved by

25 determining the speed at a speed measurement time with the detector and operating the camera to store still images during an image timing cycle. Synchronization occurs by operating the field processor to transmit the trigger signal within the timing cycle that also coincides with the speed measurement time.

30 In another embodiment of the method, the method includes determining the classification of the vehicle, such as with a separate



classification sensor (e.g., a height sensor). The classifications may include private or lower weight vehicles, commercial trucks or higher weight vehicles, and other classifications that may be used by governments in establishing differing speed limits (e.g., 55 mph for commercial vehicles and 65 mph for private vehicles). In this embodiment, the processing of the speed data includes first identifying the classification of the vehicle (such as from the combined speed data string including vehicle speed, range of vehicle from speed detector, and the vehicle type) and then comparing the detected speed with the speed limit for that type of vehicle. Vehicle classification in the method may be achieved in many ways. For example, vehicle classification may include sending a signal directly to the field processor from a separate sensor configured to detect vehicle type or classification may include concatenating vehicle type information onto the laser speed detector data string.

#### BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic block diagram illustrating an implementation of a speed measurement and image capture system according to the present invention.

FIG. 2 is an illustration of a display screen of the portable field processor of FIG. 1 as it would be viewed by an operator of the processor and by a vehicle driver.

FIG. 3 is front perspective view of an embodiment of the speed measurement and image capture system of FIG. 1 illustrating the compactness of the system as the entire system is mounted on a standard photographers tripod.

FIG. 4 is a rear perspective view of the system of FIG. 1 similar to FIG. 3 illustrating the operator's view of the system and showing the field processor housing for holding and viewing the portable field processor.

FIG. 5 is rear side view of the system of FIGS. 3 and 4 illustrating the detachable mounting bracket and the communication and power ports or connections of the system components.

FIG. 6 is a flow diagram illustrating the acts and features of operating the speed measurement and image capture system to capture and process images and then display the images to a vehicle operator with portable field processor.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

5           Figure 1 illustrates one embodiment of a speed measurement and image capture system 100 that is especially configured to be used in the field by law enforcement officers. In this regard, the system 100 includes components that can be combined into a compact and portable unit for ready mounting on a tripod or onto a bracket of a vehicle. Significantly, the system  
10   100 also includes a portable field processor 110 that is designed to receive digital information (i.e., captured digital images and detected speeds and ranges), to process the information (such as by zooming in on a vehicle operator's face and/or a license plate on the vehicle), and to be detached from the system 100 to be carried over to the vehicle. The captured and  
15   processed image can then be easily displayed to the vehicle operator on a display screen 112 of the portable field processor 110. These and other features, such as the use of a digital camera battery to trickle feed power to the portable field processor 110 to enhance data storage and security, will be discussed in detail below. An overview of the system 100 will first be  
20   provided followed by an in depth discussion of the individual components of the system 100 and their operation.

As illustrated, the speed measurement and image capture system 100 includes a portable field processor 110 in communication with both a laser speed detector 130 and a digital camera 140. As will become clear, the laser  
25   speed detector 130 is utilized by the portable field processor 110 to obtain a speed of a moving vehicle 134 and the vehicle's range or distance from the detector 130. Concurrently, the digital camera 140 is operated by the portable field processor 110 to capture an image of the front portion of the vehicle 134. During operation, the digital image is combined with the  
30   detected speed and range information by the portable field processor 110 for

use in proving that a vehicle was going the detected speed (e.g., violating a posted speed limit).

The laser speed detector 130 may be any of a number of laser-based speed and range detection devices that are useful for determining speed and range of a vehicle or other object from the detector 130 at the time the determination was made. Additionally, the detector 130 preferably is configured to provide the determined speed and range information over a communication link to the input/output port 122 of the portable field processor 110 (e.g., in digital form). In one preferred embodiment, the laser speed detector 130 is a laser-based sensor device such as that available from Laser Technology, Inc., Englewood, Colorado under the product name of UltraLyte, which operates effectively to determine the speed and range measurement data and to download the data to the portable field processor 110 (e.g., at a baud rate of 9600 or higher). As shown, the portable field processor 110 includes memory 120 for storing the speed and range measurement data from the laser speed detector 130.

The digital camera 140 is a significant feature of the system 100 providing the key functions of capturing and delivering a digital image when prompted by the portable field processor 110 and of acting as the charging power supply for the portable field processor 110. The digital camera 140 is preferably fully programmable and is selected to create a digital still image on demand and to download the image (e.g., a compressed digital file such as JPEG file) to the portable field processor 110, which can append the speed and range information to the digital image file such as in the JPEG file header.

The digital camera 140 is included to provide the proof that the correct vehicle 134 has been targeted by the laser speed detector 130 by taking or capturing a digital image of the vehicle 134 as the speed is substantially concurrently (i.e., within an acceptable time window, as discussed below) being determined by the detector 130. In other words, the operation of the digital camera 140 and laser speed detector 130 are synchronized by the portable field processor 110. The digital camera 140 includes a lens 142

which is selected such that the camera 140 can capture vehicle images which can be resolved to accurately show the vehicle license plate (and in some embodiments, the vehicle operator's face). The digital camera 140 has a range or field of resolution that preferably coincides with, or is larger than, the target area of the laser speed detector 130 (e.g., a range of 0 to 125 meters or more). The digital camera 140 is powered by an integral battery 144, which is also used to provide power to the portable field processor 110 via power supply port 124 as is discussed in detail below.

As with the laser speed detector 130, the digital camera 140 may take many forms and configurations to provide the features and operational advantages of the present invention. In one embodiment, the digital camera is a high-speed Ethernet camera (such as those available from JVC under Model No. VN-C1U) that is interfaced with the portable field processor 110 with a network card (such as a Compact Flash network card) in the input/output 122 of the processor 110. This type of digital camera is desirable for the camera 140 because it has a high data transfer speed and is programmable but many other digital cameras may be employed in the invention. In one preferred embodiment, the camera 140 is operated in a mode to automatically compress captured images into a JPEG format which reduces the file size of the images prior to them being transferred to the portable field processor 110. The initial setup (e.g., parameter setup) and image capture request communication from the portable field processor 110 to the camera 140 is typically performed via an Ethernet connection (e.g., a 10Base-T Ethernet LAN) with UDP or other protocol to provide a connection rate useful for rapidly downloading the digital images from the camera 140 to the processor 110.

The camera 140 preferably is able to operate in an automatic mode and in a manual mode. In the automatic mode, the camera 140 automatically adjusts the exposure, gain, brightness, and other operating parameters to provide a high quality image. In manual mode, the camera 140 can be adjusted by an operator or by the processor 110 to set a number of operating

parameters. For example, the following parameters may be set (with one preferred setting provided in parentheses): image resolution (640 x 480 pixels); JPEG compression (low or best resolution for camera 140); exposure (1/1000 second); gain (minimum=150, average setting=200, and  
5 maximum=255); frame rate (maximum for camera 140 such as 30 frames/second); contrast (default of camera 140); brightness (median setting for camera 140); and sharpness (default of camera 140). Other operating parameters and settings will be apparent to those skilled in the art to obtain a clear enough image to identify a license plate and/or vehicle operator.

10 In this regard, a number of lens systems 142 may be utilized to obtain a desirable captured image, such as a lens system with a 225-millimeter focal length. In a preferred embodiment, the lens system 142 provides a full field-of-view of 1.5 degrees and is focused at 80 meters to obtain sharp images from 50 to 120 meters. Of course, the focus distance is preferably matched  
15 to the target field capacity and setting of the laser speed detector 130. In practice, the only camera 140 adjustment that is manually performed in the field is adjustment of the aperture. Other operating parameters, such as gain, are set by an operator of the system 100 via the portable field processor 110 by entering information in a capture setup screen (discussed in more detail below).

20 According to one important feature of the invention, the system 100 is configured such that the digital camera 140 functions as a charging power source for the portable field processor 110. This arrangement enables the processor 110 to be fully charged even when the digital camera 140 does not have enough power to continue to operate (i.e., when its battery 144 is  
25 depleted) which provides an added level of data protection for previously captured images and speed and range information with data loss being unlikely. This charging feature may be carried out in a number of ways, and the following embodiment is exemplary only and not limiting of the breadth of the invention.

30 In one embodiment, the camera 144 includes a battery 144 that provides the needed input power for operating the camera 140. For example,

the battery 144 may be a readily available 7.2 VDC rechargeable lithium ion battery or other type and rating battery that can be mounted to the camera 140. In some embodiments, the camera 140 operates at a different power level than provided by the battery 144 (or desired by processor 110) and a  
5 step-down regulation board (not shown) is mounted between the camera 140 and the battery 144 (e.g., the camera 140 may require 5 VDC input power and the step-down regulation board would be configured to step down the 7.2 VDC to 5 VDC). Further, a switch (not shown) may be provided to break the connection between the battery 144 and the regulation board.

10 To provide a trickle charge to the processor 110, the stepped-down voltage may be provided to the processor battery system 126. As illustrated, the battery 144 is connected directly to the power supply port 124 that feeds the charging power to the battery system 126 of the processor 110. A step-down regulator (not shown) may be provided in the processor 110.

15 Alternatively, the stepped-down power from the regulation board (not shown) in the camera 140 can be fed through the communication line to the input/output port 122 of the processor 110. For example, the processor 110 power supply wiring may be included in the Ethernet communication wiring from the camera 110 with the stepped-down power (such as 5 VDC) being  
20 brought into the processor 110 through the input/output port 122 (e.g., a serial connector port).

Turning now to the portable field processor 110, the system 100 is uniquely configured such that the speed of the vehicle 134 can be accurately determined and an image captured with the detector 130 and camera 140.  
25 This data is downloaded to the portable field processor 110, which can be removed or detached from the system 100 and easily carried over to the vehicle 134 by a system operator to display the captured image with the determined speed to the vehicle operator. To achieve these and other functions, the processor 110 includes an input/output port 122 for  
30 communicating with the detector 130 and camera 140. The port 122 (e.g., an RJ45 socket) may be configured with a Compact Flash network card, such as

those available from Socket (e.g., a Socket, part number EA2902-139 Ethernet card), that in one embodiment is an Ethernet card selected to provide 10BaseT communications with the camera 140. Preferably, the communication cable from the port 122 is ruggedized such that there is no connector to reduce the chance of a communication malfunction during field operations. Of course, the cable connections discussed and illustrated may be replaced with infrared (IR) links between the processor 110 and one or both of the camera 140 and the detector 130.

The processor 110 is preferably a small, handheld computer device or palmtop computer that provides portability and is adapted for easy mounting (as discussed with reference to Figures 3 and 4). For example, any of a number of personal digital assistants (PDAs) may be utilized for the processor 110. As illustrated, the portable field processor 110 includes a display and input/output screen 112 for use by the operator in displaying an image and speed and range information to an operator of the vehicle 134.

Figure 2 illustrates one embodiment 200 of a screen shot displayed on the display 112. The captured image includes an image of the vehicle 134 and in this embodiment, the captured image has been processed by the processor 110 to zoom in or enlarge the portion of the captured image that shows the license plate 204 of the vehicle 134. The collected speed and range data and other operator-entered data (e.g., capture session parameters) are shown in an information section 208 of the screen 112 to provide quick verification that the speed determined has been matched to the correct vehicle 134.

Operation of the processor 110 to process the captured image is discussed below with reference to Figure 6, and preferably includes the ability to select portions of the captured image received from the camera 140 for modification (e.g., to show clearly the license plate 204 and/or the face of the vehicle operator). While many screen or display technologies may be employed, one embodiment uses a reflective TFT screen that uses sunlight for illumination to enhance outdoor performance. The display 112 is used

during operation to enter data (such as camera operating parameters and capture session parameters) and may use stylus, touch screen, and keyboard functions commonly available with PDAs for entering and manipulating data (e.g., selecting items in menus).

5           The processor 110 includes a central processing unit (CPU) 114, such as a 71 MHz MIPS R4000 or a 206 MHz Intel Strongarm 32-bit RISC processor, to perform the logic, computational, and decision-making functions of the field processor 110 including interpreting and executing instructions. Memory 120 is provided for use during software execution and for storing  
10   digital image files from the camera 140, speed and range information from the detector 130, and capture session parameters entered by an operator. In one embodiment, memory 120 comprises 24 or more MB memory with 8 MB for program execution and the remaining 16 MB for data storage. An operating system 116 is provided to manage the basic operations of the field processor  
15   110 and in a preferred embodiment is the Windows™ CE 3.0 or newer operating system available from Microsoft, Inc., Bellevue, Washington that is configured to support UDP protocol for communicating with the detector 130 and camera 140.

          A system coordinator 118, e.g., operating software, is provided to  
20   coordinate the activities of the system 100. The system coordinator 118 preferably is configured to allow an operator of the processor 110 to set and modify system operating parameters, to browse previously captured images, and to capture new images of vehicles 134. Numerous programming languages may be utilized, and in one embodiment, the system coordinator  
25   118 is written in Visual C++ and compiled for the MIPS or StrongArm processor 114 and the specific operating system 116 (e.g., Windows™ CE).

          As noted earlier, the combination of a digital camera 140 and a laser speed detector 130 with digital data output significantly simplifies the act of combining the speed and range data (and capture session data input by an  
30   operator) with the digital image file from the camera 140. This is a large improvement over prior art devices that utilized video-based image capture



and then employed a processing hungry and/or time consuming and complex series of steps to overlay the digital information over a captured frame of the video image of a vehicle. Additionally, synchronization of the operation of the detector 130 and camera 140 is simplified by the inclusion of digital  
5 photography technology in the system 100. Synchronization is important to accurately match captured images with determined speed and range data.

In one embodiment, the system coordinator 118 achieves the combination of the speed data with the image by inserting the speed and range data into the digital image file header. Alternatively, the combination of  
10 data may be completed by and at the digital camera 140. In this embodiment, the laser speed detector 130 is communicatively linked to the camera 140 to receive operating instructions (e.g., range-gate information) from the processor 110 as well as for passing the determined data to the processor 110 via camera 140.

15 In addition to the speed and range data, a number of other operating parameters and capture session data (such as that illustrated in the screen portion 208) may be inserted in the image file header when the image file is processed and then stored in the memory 120 by the system coordinator 118. In one embodiment, the following information is stored in the image file  
20 header: (a) date (which is preferably automatically updated by the processor 110); (b) time (preferably updated automatically by the processor 110); (c) operator name (entered by system 100 operator using a setup screen on display 112); (d) operator ID; (e) capture location (entered by operator using setup screen indicating location for monitoring vehicles 134); (f) determined  
25 speed (provided by the detector 130); (g) distance (provided by the detector 130); (h) speed limit (entered by operator using setup screen); X and Y crosshair positions (automatically entered during the alignment process to show detection point of detector 130); and camera ID (entered by operator and may include camera 140 serial number).

30 The systems coordinator 118 preferably allows the operator to set different modes of operation of the system 100 to selectively store chosen

images. In one mode of operation, the operator may select "all" which indicates that during a capture session all speed data for vehicles determined to being going equal to or above the captured speed are stored in a log file in memory 120 for statistical or other uses. The "all" setting may be useful for  
5 automated and non-monitored operation of the system 100 (such as setting up the system 100 at a location for a period of time to monitor general traffic patterns and then retrieving the system 100 or the memory 120 at a later time).

To reduce the number of image files (with added header information) stored in memory 120, the operator may enter capture parameters such as a  
10 capture level that indicates the amount over the entered speed limit that should be captured. For example, the capture level may be set at 0 mph, and all vehicles 134 determined to be moving at a speed above the entered speed limit are captured. More preferably, a capture level such as 5 or 10 mph is entered to reduce the number of image files captured, processed, and stored  
15 in the processor 110 but yet to capture the vehicles 134 that are exceeding the entered speed limit by a level that indicates a citation or ticket should be issued. This mode of operation is suitable for both unmonitored operation and for monitored operation (i.e., in which an operator monitors operation with the capability of stopping a capture session to process and display an image  
20 to a particular vehicle operator).

Referring again to Figure 1, the system 100 may include a field printer 150 to allow the processor 110 to transmit an image print file to the printer 150 to print screen images or other files in the field. For example, a thermal printer can be connected to the serial port of the processor 110 (or to the field  
25 processor housing 310, discussed below). Additionally, the system 100 may include a base station 160 in communication via link 156 (a wired or wireless link that may include a direct connection such as by taking the processor 110 to a home office containing the base station 160 or a communications network such as the Internet) to the portable field processor 110. The base  
30 station 160 may include one or more computer systems configured with software and processing components to enable the base station 160 to

access and process the image files in memory 120 (or alternatively, the memory 120 may be removed and taken to the base station 160). This enables an operator of the base station 160 to browse the image files or to sort the files based on capture sessions and/or speeds (or speed to speed  
5 limit differentials) for creation of citations or tickets.

According to a preferred embodiment of the invention, the base station 160 includes software and processing capacity to be able to process the digital image files to enhance the images to improve clarity without modifying the original files. New screen images are created that may include enlarging  
10 selected portions of the image (such as the license plate area or operator area of the vehicle 134) and changing the contrast of the image to provide a higher quality picture of the vehicle 134. The base station 160 can then print the enhanced or unenhanced image with all or select portions of the embedded text using any suitable printer.

15 According to another feature of the illustrated system 100, a vehicle classification sensor 170 is provided that is configured to discriminate between different classifications of vehicles. In many situations, governments enforce two or more different speed limits. For example, in the United States, a 65 miles per hour (mph) speed limit may be enforced for vehicles under a  
20 certain height, weight, or axle number (typically, called private vehicles) while in the same location, a 55 mph speed limit is enforced for vehicles over a certain height, weight, or axle number (typically, called commercial vehicles). In these locations, it is useful to first differentiate or classify the vehicles into the classifications used to set and enforce the differing speed limits and then  
25 to only capture those that are meeting or exceeding the speed limit (e.g., capture level). Without this ability, the vehicles violating the lower speed limit are typically not captured or a large amount of manual processing is used to eliminate all the vehicles not speeding when the lower speed limit is used as the capture level.

30 Referring to Figure 1, the system 100 is shown to include a vehicle classification sensor 170 configured for sensing a characteristic of the vehicle,

such as height, weight, axle number, and the like. The sensor 170 may be configured to transmit a signal providing this characteristic data to the input/output 122 of the portable field processor 110 (automatically or upon request from the processor 110). In a preferred embodiment, the vehicle  
5 classification sensor 170 is configured to determine the classification of the vehicle and to then transmit the vehicle type information to the portable field processor 110. This vehicle classification signal may be sent directly or the information may be concatenated with the laser speed detector 130 speed data (e.g., the combined data string may include vehicle speed, vehicle range  
10 from detector 130, and vehicle type).

While many vehicle sensor configurations may be utilized to practice this feature of the invention, the illustrated sensor 170 is useful for sensing the height of the vehicle 134. In this regard, the sensor 170 typically is mounted and aligned within the system 100 to sense when a vehicle 134 is at  
15 or above a height limit, such as 6 to 9 feet (i.e., whatever vehicle height is used by the government for setting the lower speed limit).

The portable field processor 110 then processes the vehicle type information along with the vehicle speed data to determine if an image should be captured. For example, the portable field processor 110 may be  
20 configured to first identify the vehicle type or classification and then retrieve from memory 120 a vehicle speed limit for the classification. In a more preferred embodiment, the operator of the portable field processor 110 inputs capture levels for each possible vehicle classification. In this embodiment, once the processor 110 identifies the vehicle classification from the signal  
25 from the sensor 170, the processor 110 compares the received vehicle speed with the appropriate capture level to determine if an image should be captured. In this manner, the system 100 enables effective and accurate vehicle classification and capture of speeding vehicle images in locations having more than one enforced speed limit.

30 According to another useful aspect of the system 100, the portable field processor 110 may be configured to transmit wireless signals to remote

field locations to enhance speed enforcement. In practice, the portable field processor 110 and the digital camera 140, and the detector 130 may be positioned to capture images of speeding vehicles at a first location on a road while the enforcing officer may be positioned at a second location remote from the processor 110, such as 100 to 200 meters or further down the road from the processor 110. With this positioning, the enforcement officer can be informed with a signal from the processor 110 of an approaching speeding vehicle 134 and more importantly, be provided with the combined vehicle speed data and image file for use in stopping and ticketing the vehicle 134.

In this regard, the portable field processor 110 is shown in Figure 1 to include a wireless output 174 for transmitting a wireless signal 176 to a remote field receiver 180. As discussed above, the wireless signal 176 preferably includes the combined speed data and image file (explained in detail previously). The remote field receiver 180 may be any wireless device configured for receiving a wireless signal, and in one embodiment, is a device similar to the portable field processor 110 that is useful for processing and displaying the captured image and speed data to an operator of a vehicle 134. A thermal printer may also be used at the remote location to print out hard copies of the image and speed data. A number of well-known wireless network devices and technologies can be utilized for the wireless output 174. Similarly, a number of digital wireless protocols may be used, such as CDMA, GSM, iDEN, CDPD, and Bluetooth.

Referring now to Figures 3-5, one embodiment of the speed measurement and image capture system 100 is illustrated that clearly shows the compact and portable nature of the system 100 that is achieved, at least in part, through the combined use of the digital camera 140 and the portable field processor 110. As shown, the system 100 can readily be mounted on and supported by a standard tripod 330 (such as a photographer's tripod). Due to the lightweight and compact characteristics of the system 100, the system 100 alternatively can be simply hand-held by an operator, be mounted on a number of stand arrangements besides the illustrated tripod 330, or be

mounted directly to a vehicle with the use of a receiving bracket (not shown) attached to the vehicle.

As shown in Figures 3-5, the system 100 is mounted to the tripod 330 utilizing system mounting bracket 320 in a manner that balances the system components to enhance stability. Additionally, the mounting bracket 320 includes a quick release plate 322 that is configured to engage the tripod 330 such that the plate 322 can be mounted rapidly and optionally fastened to the tripod 330 to lock the plate 322 in position. In the illustrated embodiment, the plate 322 is configured to slide into grooves in the tripod 330 and fasteners can be inserted through holes in the plate 322 to rigidly attach the bracket 320 to the tripod 330.

To distribute the weight of components and enhance stability, the illustrated bracket 320 is adapted to facilitate mounting of the detector 130, the digital camera 140, and the field processor 110 (along with any protective housing 310) on the tripod 330 (or other support structure) such that the mounted system 100 is stable. Further, it is preferable that the mounted system 100 remain relatively stable with or without the field processor 110, as a key feature of the invention is being able to remove the field processor from the system 100. Many alternative arrangements can be envisioned for maintaining a stable mounting of the system 100 on a bracket 320, and these alternative mounting arrangements are considered within the breadth of this disclosure.

In the illustrated embodiment, the bracket 320 is configured such that the typically heavier detector 130 is mounted substantially above the quick release plate 322. This enhances the stability of the mounted system 100 by placing the heaviest component on or substantially on a central axis of the tripod 330 (or on an axis passing through the center of gravity of the tripod 330). The digital camera 140 is then mounted on the bracket 320 adjacent a first side of the detector 130 and a field processor housing 310 for housing the processor 110 is mounted on the bracket 320 adjacent a second side of the detector 130. This configuration provides weighted stability for the

mounted system 100 with the processor 110 positioned within or removed from the housing 310.

Additionally, mounting the camera 140 to the same bracket 320 as the detector 130 facilitates mechanical alignment of the two components such that captured vehicle images more readily correspond to the vehicles 134 for which speed is detected. When the camera 140 is attached to the bracket 320 (or the portion or arm of the bracket 320 that is supporting the detector 130), the camera 140 can be adjusted vertically and horizontally to be substantially parallel with the sighting device of the detector 130. Alignment can be achieved by first sighting the detector 130 on a stationary object and then second sighting the camera 140 on the same object (or in opposite order). Once mechanically aligned, the two devices 130 and 140 are preferably locked in place, such as with fasteners, such that alignment is only required upon initial set up. Final alignment (or refined camera targeting) of the camera 140 is preferably achieved with the systems coordinator 118 of the processor 110 which can operate to position digital image crosshairs onto a specific feature of a sighted object. The crosshairs indicate the detection location of the detector 130 on an image captured by the camera 140.

As discussed with reference to Figure 1, the detector 130 and camera 140 communicate with the portable field processor 110. As shown, the detector 130 includes a communication port 520 and the camera 140 includes a communication port 530 (although in some applications IR links may be utilized). Standard communication cables (not shown) are then used to connect the detector 130 and camera 140 to the communication port 502 (illustrated as a serial port) of the field processor housing or enclosure 310. The portable field processor 110 (not shown in Figures 3-5) is positioned or plugged into the base 312 of the housing 310 to provide for communication with the detector 130 and camera 140 (as discussed with reference to Figure 1). A protective cover 314 is provided that can be open, such as with hinges, to allow access to the interior portion of the base 312 for insertion and removal of the processor 110 during operation of the system 100. In this

manner, the processor 110 is protectively housed in the housing 310 with docking for communication with the detector 130 and camera 140 but yet can readily be detached or unplugged from the housing 310.

5 The protective cover 314 includes a viewing window 318 to allow the cover 314 to be closed to protect the processor 110 from weather and dust during field use of the system 100. To enter data, the cover 314 is typically opened to provide access to the display 112 of the processor, and for use with many processor 110 configurations a stylus holder 316 is provided on the side of the base 312 to hold the stylus-type data input tools provided with  
10 palmtop computers and PDAs. An optional cover locking knob 514 is provided to lock the cover 314 in the closed position.

Preferably, the camera 140 also provided charging power to the processor 110. As illustrated, the camera 140 includes a power outlet port 534 which is connected with a cord (not shown) to the power supply port 124  
15 of the housing 310 and processor 110. In another preferred embodiment, the trickle charging power is provided over the communication cable and fed into the processor 110 over a standard communication port (e.g., serial port 502). In this embodiment, only one cable is needed to transfer data (i.e., digital image files and parameter data) between the camera 140 and the housing  
20 310 and to transfer power from the camera 140 to the housing 310. The single cable would connect the communication port 530 of the camera 140 to the communication port 502 of the housing 310 (which in turn, is connected to the communication port, typically a serial port, of the processor 110 when the processor 110 is docked within the housing 310). Also, as discussed with  
25 reference to Figure 1, in some embodiments a short communication cable (not shown) is used to communicatively link the detector 130 to the camera 140 to reduce the length of cabling required. In this embodiment, the processor 110 exchanges data with the detector 130 through the camera 140 communication cable and port 530.

30 Referring now to Figure 6, operation of the speed measurement and image capture system 100 will be discussed to provide a further



understanding of the unique features of the invention. At 610, the operation process 600 is started with initial set up of the portable system 100. Initial set up may involve numerous steps such as the mounting of the system 100 on the bracket 320 and/or tripod 330, but generally involves selecting a capture session location in which to monitor vehicle traffic (such as adjacent a road within the system's targeting area and with the sun striking the rear of the detector 130 and camera 140 to control glare and to better illuminate license plates) and setting up, connecting, and powering up the components of the system 100. A portion of a road may be targeted and vehicles automatically targeted and/or captured as they cross into the capture area or target line or alternatively, an operator may target manually specific vehicles by changing the position of the system 100 (e.g., turning the system 100 on the tripod 330).

At 614, the operator is requested via a menu or other data entry device on the display screen 112 of the processor 110 to select an operating mode. A number of operating modes may be included for operation of the system 100 such as a browse mode that allows the operator to view previously captured images and a system mode that allows the operator to enter or modify system settings (such as adjusting the camera 140 settings, the detector 130 settings, the images to be logged or stored (such as only vehicles above a capture limit indicating speeding) and the like). If these modes are selected, once the operator is finished entering information or viewing (and processing and printing) images, the process 600 ends at 618. To capture new vehicle images and speeds, the operator at 614 selects capture mode (or continue previous capture mode) and at 618 the process 600 is continued.

At 622, the operator is requested via a data entry screen on the display 112 to enter capture session information or parameters. A portion or all of these parameters will then be inserted by the system coordinator 118 into the captured image file (such as in the header of a JPEG file) for inclusion in the captured image files stored in memory 120 and/or shown to vehicle operators. A wide variety of parameters may be included but in one embodiment, the

parameters include an operator name, an operator ID, a capture session location, the posted speed limit for the location, the capture level or capture speed limit (i.e., a speed value for which the system 100 will capture an image when the determined speed by the detector 130 is greater than or equal to the speed value), weather conditions (which in some embodiments is used by the system coordinator to automatically determining camera 140 settings such as camera gain), and the camera 140 serial or identification number.

At 626, the capture session is begun. The system 100 is either positioned to automatically detect vehicles 134 that enter a target area or the operator of the system 100 may move the system 100 to target particular vehicles 134 (such as by turning the upper portion of the tripod 330). When a targeted vehicle's speed and distance from the detector 130 are determined by the detector 130, this information is transmitted to the processor 110 (e.g., via a communication connection such as RS232). The system coordinator 118 compares the determined vehicle's speed with the entered capture level or capture speed limit for the capture session. If the determined speed is less than the capture speed limit, no image is taken, i.e., the camera 140 is not operated to capture an image (unless all images and speeds are being logged for monitoring traffic patterns). If the determined speed is equal to or greater than the capture speed limit, the system coordinator 118 of the processor 110 transmits an operational signal to the camera 140 to trigger the camera 140 to capture an image of the vehicle 134. The camera 140 retrieves the current digital image file from its memory and downloads the digital image file (e.g., a JPEG file) via the Ethernet or other connection to the processor 110.

The image capture step 626 may also include first classifying the vehicle 134 into classifications, such as private and commercial, used by a government agency for establishing two or more speed limits (e.g., capture levels). This classification is performed by the processor 110 or the vehicle classification sensor 170 based on detected information by the sensor 170 (such as vehicle being above a certain height, above a weight limit, or having

more than a set number of axes). The processor 110 then acts to first retrieve or identify the classification of the vehicle and then compare the vehicle speed with the appropriate capture level.

5        Within the image capture process 626, it is important to synchronize image capture by the camera 140 with detection of speed by the detector 130. Typically, laser speed detectors 130 operate on a measurement cycle as measured from the start of individual laser shots or transmissions to the calculation of the speed and distance. A typical laser speed gun or device  
10        may have a measurement cycle of about 300 milliseconds to 400 milliseconds (with some devices having shorter and some longer cycles). The speed and distance data are transmitted to the processor 110 at the end of this measurement cycle. Hence, the time from the start of the measurement process to the export of the data is at least about 300 milliseconds and typically less than about 400 milliseconds.

15        To achieve synchronization, the digital camera 140 is preferably programmed such that the image is not taken for a time period greater than the shortest portion of the detector measurement cycle (i.e., about 300 milliseconds for the above illustrative examples). Also, a maximum latency time (i.e., time between triggering signal received at camera 140 and taking  
20        picture) is selected such that the detector 130 would most likely not have been aimed at a new target or automatically tracked on a new target vehicle. In one embodiment, a maximum latency time of 200 milliseconds is utilized, but it is understood by the inventors that smaller and larger latency times may be selected to provide acceptable synchronization of the camera 140 and  
25        detector 130. In this embodiment, an image capture window is established that begins at about 300 milliseconds before the end of the measurement by the detector 130 and that ends at about 200 milliseconds after the trigger signal to the camera 140.

30        With this image capture window established, the camera 140 is preferably programmed in combination with operation of the system coordinator 118 (which transmits the camera trigger signal) such that the

camera timing cycle coincides with the image capture window to place an image frame containing the vehicle 134 for which speed was measured within the memory of the camera 140. The camera timing cycle in one embodiment is approximately 200 milliseconds with the image frame being placed in memory as  
5 early as 100 milliseconds prior to the end of speed measurement by the detector 130 and as late as 100 milliseconds after the end of speed measurement.

This timing cycle is obtained by the systems coordinator 118 adding a time delay, such as 100 milliseconds, from the time the detector 130 completes and transmits the speed measurement to the processor 110.  
10 Another phase of the timing cycle is established by the camera 140 which updates a compressed image into alternating buffers periodically, such as every 200 milliseconds. If the camera trigger signal is received just before the next update, the image would be 200 milliseconds old (or 100 milliseconds prior to the end of the speed measurement). Conversely, if the camera  
15 trigger signal is received as soon as the buffer is updated, the image is frozen immediately (or 100 milliseconds after the end of the speed measurement). Of course, those skilled in the art will understand that the camera timing cycle, the image capture window, the timing of the camera trigger signal, and the speed measurement cycles will vary with particular components chosen  
20 for the system 100 and with the programming and operating setting of each component. These variations are acceptable in practicing the invention as long as the image capture and speed determination events can be adequately synchronized such that the same vehicle is captured in an image file and is targeted for speed determination.

25 As discussed with reference to Figure 1, a significant feature of image capture is the combination of the image file from the camera 140 with the speed and distance data from the detector 130 and other system and/or capture session parameters. Typically, the data combination is completed at the processor 110 by the system coordinator 118 which functions to write or  
30 insert the speed and distance information into the header of the image file (e.g., JPEG-formatted file). The system coordinator 118 also writes select

portions of the system parameters (such as time and date) and capture session parameters (such as location, speed limit, and operator ID) into the digital image file header. Generally, after the digital image file header is modified or the information is otherwise appended to the digital image file, the  
5 modified digital image file is displayed on the display 112 of the processor 110 for viewing by the operator.

In one preferred embodiment, the operator at 626 can operate the processor 110 to zoom in or enlarge select portions of the displayed image file. For example, the operator may select the license plate portion or the  
10 driver's side of the windshield to enlarge one of these portions of the displayed image. Various image enhancing tools may also be provided in the processor 110, and if included, the operator can enhance the image by altering the displayed contrast, brightness, and other characteristics useful to make a clearer and sharper image.

15 In some applications, the system 100 is allowed to operate for a period of time automatically capturing images of vehicles (all or only those above the capture limit) and combining speed and distance image and select system parameters with the digital image files. These captured and modified digital image files are then stored in memory 120 for later viewing and processing.  
20 This later viewing and processing can occur in the field via the processor 110 and/or the optional field printer 150. Alternatively, at 638, the images stored in the memory 120 (i.e., capture session data) are downloaded from the processor 110 to a base station 160. The downloading may be completed remotely over a communications network 156 or directly by interconnecting  
25 the processor 110 to a computer system within the base station 160 or by removing the memory 120 for use in the base station 160. At the base station 160, the combined image files can be sorted by determined speeds, by differentials between determined speeds and speed limits, by location, or by other information appended to the image file (e.g., inserted in the image file  
30 header). The images may also be processed to enhance picture quality and to enlarge select portions of the image. The electronic or hard copies of the

processed images may then be used as part of a citation or ticket transmitted to the vehicle owner or operator.

Alternatively, according to a significant feature of the system 100, the portable field processor 110 may be used by an operator to provide proof in the field that a vehicle was violating a posted speed limit. At 630, the operator may interrupt an active capture session. For example, an operator may observe the displayed image on the display 112 of the processor 110 and when a speeder is displayed (above capture limit or by visual identification by the operator), the operator may stop the capture session to pull over the vehicle and issue a ticket. Alternatively, the system coordinator 118 may be adapted to provide an audio and/or visual alarm when a vehicle is detected to be driving at or above the capture limit and its image is captured. At this point, the operator detaches or unplugs the processor 110 from the housing 310 and carries the processor 110 to the stopped vehicle. The operator can display the captured image with combined data to the vehicle operator on the display 112.

Alternatively, at 630, the captured speed data and digital image may be transmitted to a receiver operated by a remotely positioned field operator (law enforcement officer). The field operator can then process the information with their equipment, such as another portable field processor 110, and stop an approaching vehicle shown in the captured image. The field operator can then display the image to the operator of the vehicle 134 as described above.

The operator of the system 110 may process the captured image to enlarge the license plate or the driver's face and to enhance the clarity of the displayed image. When the operator has completed using the processor 110 to prove a vehicle's speed to a driver, the operator docks the processor 110, located in the housing 310, to its bracket. At 634, a new capture session may be begun (returning to step 610) or the previous capture session can be resumed without having to reenter capture session parameters. After the

session is completed, the capture session data can be downloaded to the base station at 638 for further processing.

In one embodiment, a data security process is performed by the system coordinator 118 prior to writing the combined data image file to memory 120 to ensure that the image and/or speed data is not altered between the time it is collected and the time it is used in a citation or as evidence. A number of security processes may be utilized to indicate whether a data file has been altered. For example, the system coordinator 118 may perform a check sum on the data with a seed number in the header of the combined speed data and digital image file, encrypt the check sum, and append the encryption into the header of the file. Then when a saved image file is opened, it is first verified as not being altered by removing the encrypted check sum and replacing the check sum with a seed number. The same type of check sum is run on the file and the new check sum is encrypted. The two encrypted check sums are then compared to determine if alteration has occurred. Of course, numerous other security processes may be utilized to reduce the risk of data modification but the exemplary method has proven effective and is detailed enough to detect an alteration as small as inverting speed digits (e.g., changing 75 mph to 57 mph). Note, in some embodiments, security is further enhanced by verifying with the processor 110 the check sum output directly by the laser speed detector 130 with an expected check sum value.

Although the invention has been described and illustrated with a certain degree of particularity, it is understood that the present disclosure has been made only by way of example, and that numerous changes in the combination and arrangement of parts can be resorted to by those skilled in the art without departing from the spirit and scope of the invention, as hereinafter claimed. For example, the system 100 can readily be used in daylight and at night with the addition of infrared and other flash devices or flood lighting.

Further, in one preferred embodiment, the portable field processor 110 is configured such the memory 120 or a separate memory (not shown) is readily removable. For example, it may be desirable that field officers or operators have their own processor 110 and simply exchange data at the end of shifts or the operators may simply have their own removable media and share the same processor 110. This can be achieved with removable storage media, such as compact disks, floppy disks, flash cards, portable USB storage devices, and the like. The memory 120 or other memory to support this removable media may be a separate data storage device linked (such as with USB port) to the processor 110. This configuration allows ready removal of data storage media and also facilitates field restoration of the application (system coordinator 118) if lost during field use (i.e., the application may be downloaded in the field by an operator).



CLAIMS

## WE CLAIM:

1. A compact speed measurement system for field or onsite use in measuring speeds of vehicles and capturing images of select ones of the vehicles, comprising:
  - a laser-based speed detector for determining a speed of a vehicle in a target area and in response, generating a speed signal;
  - a camera aligned with the speed detector for capturing and storing a digital-format still image of the vehicle in memory, wherein the camera is adapted for responding to an image capture signal to generate and transmit a digital image file including the still image of the vehicle; and
  - a portable field processor communicatively linked with the speed detector and the camera for first receiving the speed signal and second receiving the digital image file, wherein the portable field processor is configured for processing the speed signal from the speed detector and in response, transmitting the image capture signal to the camera.
2. The speed measurement system of Claim 1, wherein the portable field processor operates to create a combined speed and image data file by modifying the digital image file to include speed data from the speed signal.
3. The speed measurement system of Claim 2, wherein the digital image file is a JPEG-format file and the modifying includes inserting the speed data in a header of the JPEG-format file.
4. The speed measurement system of Claim 1, wherein the portable field processor comprises a display screen and the portable field processor is adapted for concurrently displaying at least a portion of the digital image file and at least a portion of the speed signal on the display screen.
5. The speed measurement system of Claim 4, wherein the portable field processor is detachably mounted within the system to allow an operator to hand-carry the portable field processor to the vehicle.

6. The speed measurement system of Claim 5, further comprising a field processor housing including a processor docking base configured to receive and support the portable field processor and to communicatively link the camera to the portable field processor.
- 5           7. The speed measurement system of Claim 6, wherein the processor docking base includes a power inlet port for receiving a charging power stream and for passing the charging power stream to the portable field processor, the charging power stream being received from the camera.
- 10           8. The speed measurement system of Claim 1, wherein the portable field processor is communicatively linked to a base station and is adapted for remotely transmitting at least a portion of the speed signal and the digital image file to the base station.
- 15           9. The speed measurement system of Claim 1, wherein the portable field processor is configured to process the digital image file to dynamically enlarge a selected portion of the still image.
10. The speed measurement system of Claim 9, wherein the portable field processor is configured to process the digital image file to alter select characteristics of the still image, whereby a displayed portion of the digital image file is visually enhanced.
- 20           11. The speed measurement system of Claim 1, further including a vehicle classification sensor for sensing a characteristic of the vehicle and in response transmitting vehicle identification data to portable field processor.
12. The speed measurement system of Claim 11, wherein the processing completed by the portable field processor includes comparing the speed signal with a capture speed level corresponding to the vehicle identification data.
- 25           13. The speed measurement system of Claim 1, wherein the portable field processor includes a wireless output device for transmitting a

wireless signal comprising at least a portion of the speed signal and the digital image file to a remotely located receiver.

14. A method of measuring a speed of a moving vehicle and capturing a digital image of the same moving vehicle, comprising:

5       positioning a speed detector and a camera at a location selected for targeting vehicles moving through a target area;

operating the camera on an ongoing basis to capture still images of the vehicles passing through the target area and store the still images at least temporarily in memory;

10       determining the speed of a targeted vehicle with the speed detector;

transmitting speed data comprising the speed from the speed detector to a portable field processor;

processing the speed data with the portable field processor and in response, transmitting a trigger signal to the camera; and

15       at the camera, receiving the trigger signal, retrieving a still image corresponding to the targeted vehicle from memory, and transmitting the still image in a digital image file to the portable field processor.

15. The method of Claim 14, further including processing the digital image file with the portable field processor to insert the speed data.

20       16. The method of Claim 15, further including displaying the processed digital image file on a display of the portable field processor and further manipulating the processed digital image file to enlarge or enhance a selected portion of the displayed, processed digital image file.

25       17. The method of Claim 14, further including placing at least a portion of the digital image file and the speed data on a display screen of the portable field processor and displaying the display screen to an operator of the targeted vehicle.

18. The method of Claim 17, wherein the displaying of the display screen comprises interrupting a communication link between the portable field processor and the camera.

5 19. The method of Claim 14, further including operating the camera to provide charging power to the portable field processor to protect the speed data and the digital image file at the portable field processor.

20. The method of Claim 14, further including prior to the operating and determining, entering capture session parameters including a capture speed limit and wherein the processing of the speed data includes comparing  
10 the speed in the speed data with the entered capture speed limit and wherein the transmitting is only performed when the speed is greater than about the entered capture speed limit.

21. The method of Claim 20, wherein the capture session parameters include a posted speed limit value for the location and further  
15 including operating the portable field processor to create a combined digital image file by writing select portions of the capture session parameters including the posted speed limit value and at least portions of the speed data into the digital image file.

22. The method of Claim 14, further including entering a first  
20 capture speed limit and a second capture speed limit into memory and classifying the targeted vehicle into a first group of vehicles corresponding to the first capture speed limit or a second group of vehicles corresponding to the second capture speed limit, and wherein the processing includes comparing the speed in the speed data with the first or second capture speed  
25 limit based on the classifying.

23. The method of Claim 14, further including transmitting a wireless signal comprising at least a portion of the digital image file and the speed data to a remotely located receiver.

24. A system for determining a speed of a moving vehicle and ensuring capture of a digital still image of the same moving vehicle, comprising:

a speed detector positioned for targeting the moving vehicle in a target area and operating to determine at a speed measurement time a speed rate of the moving vehicle and generate a signal corresponding to the speed rate;

an image capture device for storing during an image timing cycle a digital still image of each vehicle passing through the target area, wherein the image capture device is responsive to a trigger signal to capture the stored image in a digital image file and to transmit the digital image file; and

a field processor apparatus for receiving the speed rate signal and in response, transmit the trigger signal to the image capture device to the image capture device, wherein the trigger signal is timed such that the image field device captures the stored image during an image timing cycle at least partially coinciding with the speed measurement time.

25. The system of Claim 24, wherein the image timing cycle is less than about 300 milliseconds.

26. The system of Claim 24, wherein the field processor apparatus is configured to combine the speed rate signal and the digital image file to create a combined speed and image file, and further wherein the field processor apparatus is adapted to perform a security process on the combined speed and image file to facilitate detection of alteration of the combined speed and image file.

27. The system of Claim 26, wherein the security process comprises inserting a seed number in the combined speed and image file, performing a check sum of the file including the seed number, and encrypting a determined check sum value, and inserting the encrypted check sum value in the file.

28. A speed measurement system for use in measuring speeds of vehicles and capturing images of select ones of the vehicles, comprising:

a speed detector for determining a speed of a vehicle in a target area and in response, generating a speed signal;

5 a vehicle classification sensor for sensing a vehicle classification characteristic for the vehicle and in response, transmitting a vehicle classification signal; and

a portable field processor communicatively linked with the speed detector and the vehicle classification sensor for receiving the speed signal and second receiving the vehicle classification signal, wherein the portable field processor is configured for processing the vehicle classification signal to select between two or more speed limit parameters and for determining whether a vehicle speed in the speed signal is greater than about the selected speed limit parameter.

15 29. The system of Claim 28, further including a camera aligned with the speed detector for capturing and storing a digital-format still image of the vehicle in memory, wherein the camera is adapted for responding to an image capture signal to generate and transmit a digital image file including the still image of the vehicle and wherein the portable field processor transmits the  
20 signal when the vehicle speed is greater than about the selected speed limit parameter.

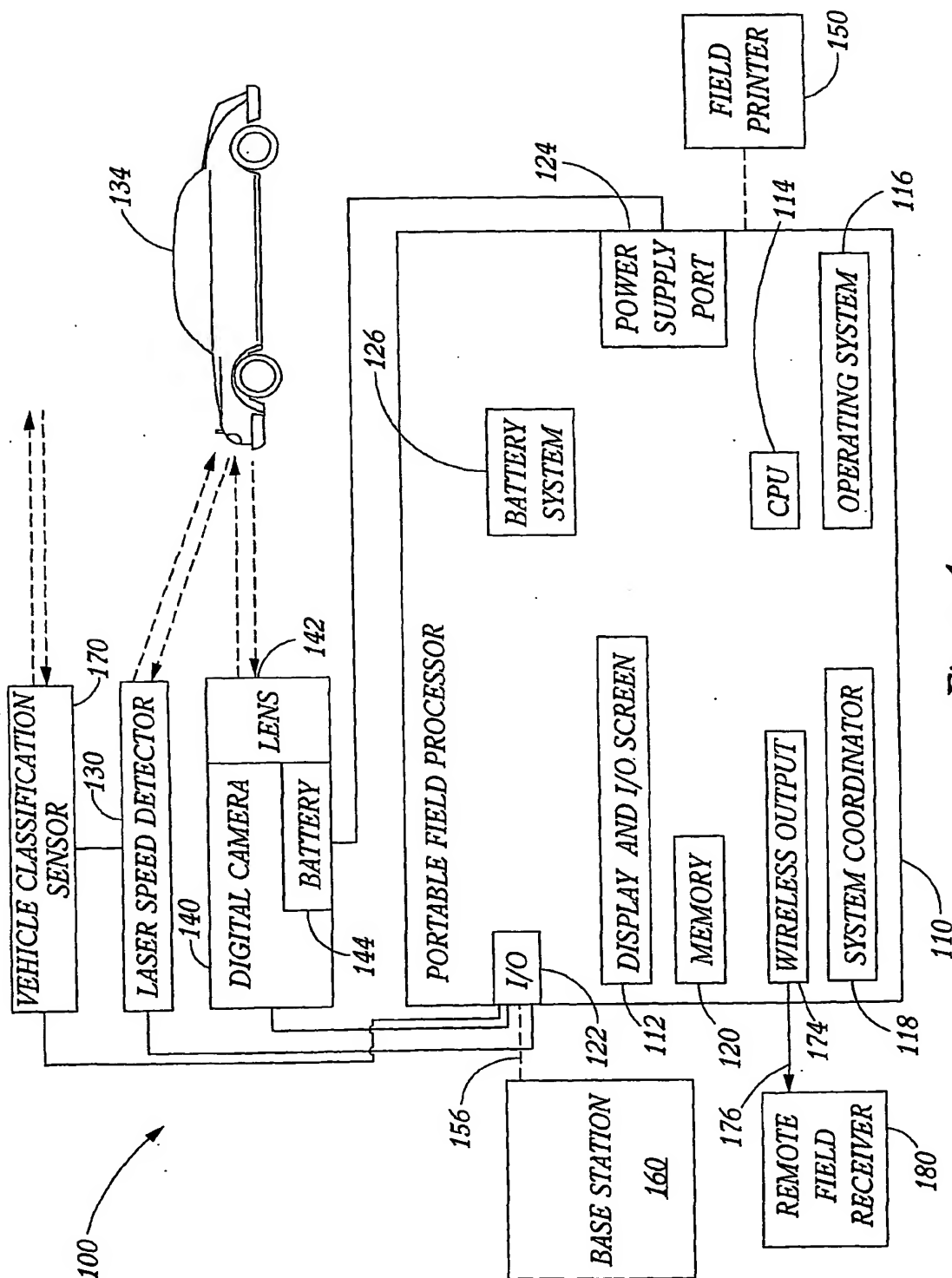
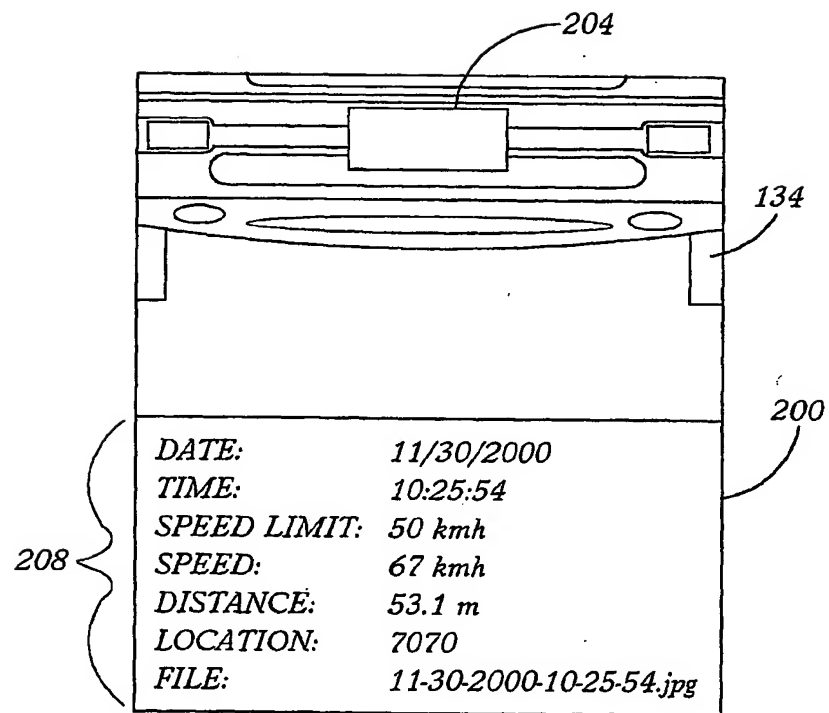


Figure 1

*Figure 2*



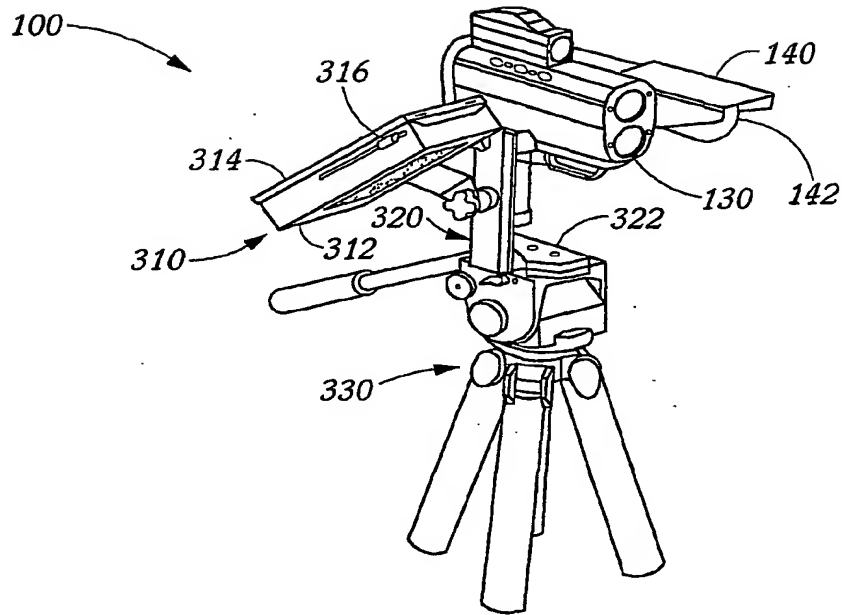


Figure 3

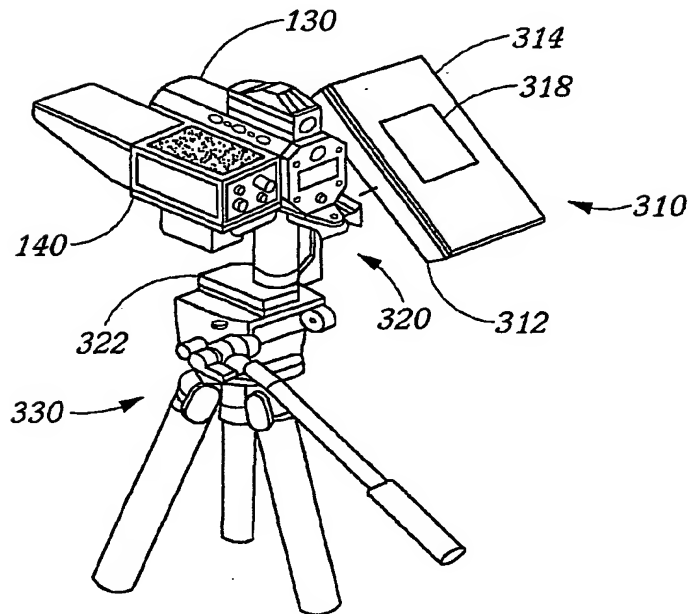
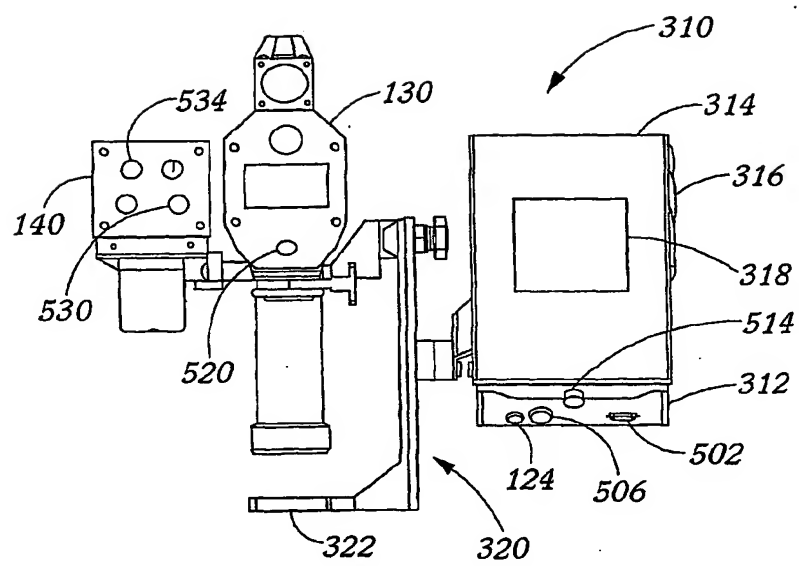


Figure 4

*Figure 5*

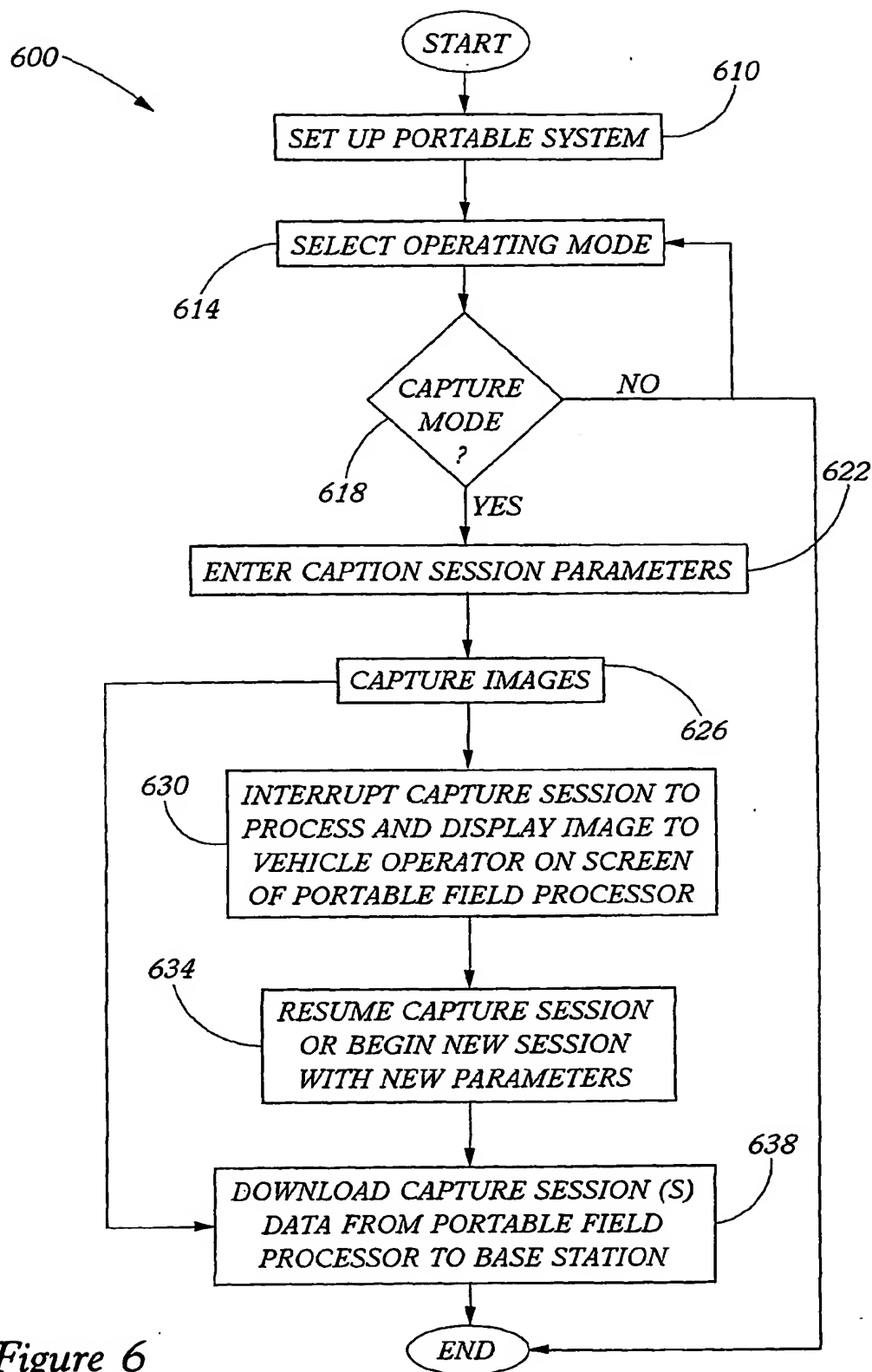


Figure 6

# INTERNATIONAL SEARCH REPORT

International application No.  
PCT/US01/08979

<b>A. CLASSIFICATION OF SUBJECT MATTER</b> IPC(7) : G06K 9/00 US CL : 382/100, 104; 340/933, 937; 342/104, 345/340 According to International Patent Classification (IPC) or to both national classification and IPC				
<b>B. FIELDS SEARCHED</b> Minimum documentation searched (classification system followed by classification symbols) U.S. : 382/100, 104; 340/933, 937; 342/104, 345/340 Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched None Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) EAST, NPL, IERE Search terms: vehicle, speed, laser, camera, jpeg				
<b>C. DOCUMENTS CONSIDERED TO BE RELEVANT</b>				
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.		
Y	US 5,583,765 A (KLEEHAMMER) 10 December 1996, column 3, lines 38-65; column 4, lines 22-65.	1-29		
Y	US 5,809,161 A (AUTY et al.) 15 September 1998, col. 4, lines 45-67; col. 5, lines 1-63; fig. 33, element 8.	1-29		
Y	US 5,531,943 A (NASBURG) 01 September 1998, col. 6, lines 1-67; fig. 36, elements 3601, 3603.	1-29		
A	US 5,983,161 A (LEMELSON et al.) 09 November 1999, col. 17, lines 10-55.	1-29		
A	US 5,529,139 A (KURAHASHI et al.) 25 June 1996, col. 4, lines 5-57; fig. 2, elements 11, 15.	1-29		
<input checked="" type="checkbox"/> Further documents are listed in the continuation of Box C. <input type="checkbox"/> See patent family annex.				
<table border="0"> <tr> <td>           * Special categories of cited documents:            *A* document defining the general state of the art which is not considered to be of particular relevance            *B* earlier document published on or after the international filing date            *L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)            *O* document referring to an oral disclosure, use, exhibition or other means            *P* document published prior to the international filing date but later than the priority date claimed         </td> <td>           *T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention            *X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone            *Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art            *G* document member of the same patent family         </td> </tr> </table>			* Special categories of cited documents: *A* document defining the general state of the art which is not considered to be of particular relevance *B* earlier document published on or after the international filing date *L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) *O* document referring to an oral disclosure, use, exhibition or other means *P* document published prior to the international filing date but later than the priority date claimed	*T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention *X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone *Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art *G* document member of the same patent family
* Special categories of cited documents: *A* document defining the general state of the art which is not considered to be of particular relevance *B* earlier document published on or after the international filing date *L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) *O* document referring to an oral disclosure, use, exhibition or other means *P* document published prior to the international filing date but later than the priority date claimed	*T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention *X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone *Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art *G* document member of the same patent family			
Date of the actual completion of the international search 19 JUNE 2001		Date of mailing of the international search report 02 JUL 2001		
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230		Authorized officer JAY PATEL <i>Rugenia Logan</i> Telephone No. (703) 305-7728		

# INTERNATIONAL SEARCH REPORT

International application No.  
PCT/US01/08979

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 6,041,310 A (GREEN et al.) 21 March 2000, col. 7, lines 25-45; fig. 1, elements 11, 19, 24.	1-29
A	US 5,938,717 A (DUNNE et al.) 17 August 1999, fig. 1, elements 11, 17, 21.	1-29
A	US 5,708,425 A (DWYER et al.) 13 January 1998, col. 3, lines 6-65.	1-29
A	US 5,742,699 A (ADKINS et al.) 21 April 1998, col. 3, lines 5-47.	1-29
A	US 5,717,390 A (HASSELBRING) 10 February 1998, col. 2, lines 45-65.	1-29
A	US. 5,852,492 A (NIMBLETT et al.) 22 December 1998, col. 5, lines 5-40.	1-29
A	US. 5,793,491 A (WANGLER et al.) 11 August 1998, abstract, lines 1-20.	1-29
A	US 5,699,056 A (YOSHIDA) 16 December 1997, col. 10, lines 7-58.	1-29

This Page Blank (uspto)

**This Page is Inserted by IFW Indexing and Scanning  
Operations and is not part of the Official Record**

**BEST AVAILABLE IMAGES**

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

- ☒ **BLACK BORDERS**
- ☐ **IMAGE CUT OFF AT TOP, BOTTOM OR SIDES**
- ☐ **FADED TEXT OR DRAWING**
- ☐ **BLURRED OR ILLEGIBLE TEXT OR DRAWING**
- ☐ **SKEWED/SLANTED IMAGES**
- ☐ **COLOR OR BLACK AND WHITE PHOTOGRAPHS**
- ☐ **GRAY SCALE DOCUMENTS**
- ☐ **LINES OR MARKS ON ORIGINAL DOCUMENT**
- ☐ **REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY**
- ☐ **OTHER: \_\_\_\_\_**

**IMAGES ARE BEST AVAILABLE COPY.**

**As rescanning these documents will not correct the image problems checked, please do not report these problems to the IFW Image Problem Mailbox.**

**This Page Blank (uspto)**